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THE VALUE AND NECESSITY

OF

EXPERIMENTS FOR THE ACQUIREMENT OF KNOWLEDGE.

OF SURGEONS

BY

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EXPERIMENTS FOR THE ACQUIREMENT OF KNOWLEDGE.

THE VALUE OF KNOWLEDGE.—It is universally admitted not only that knowledge gives power, and is therefore valuable to man, but that much of our advance in civilization, and our comforts of life, are derived from the continual discoveries of the laws which are operating on our material globe, and on all that live upon it. The physicist and the chemist are daily sending forth from their laboratories new facts which relate to heat, electricity, colours, and various useful arts; while, at the same time, the naturalist and physiologist are unfolding important laws relating to animal and vegetable life, both in their normal and diseased conditions.

The Business of Certain Persons to seek for Knowledge.—There are certain persons whose training or instincts lead them towards the constant endeavour to unravel the intricacies of Nature, and to discover its laws and operations. The impulse to do this is as strong as any passion that holds the human mind; and leads men to traverse the ocean, and explore unknown lands, in spite of a thousand dangers.

These Persons work for Truth which afterwards is made useful.—The object which the man of science places before him is the discovery or unfolding of a new truth. Its apparent insignificance does not concern him, nor the immediate advantage accruing from it. He is aware that nothing is insignificant in Nature, and that every discovery must be the exponent of some large and general law: with this he is content; he sees only the immediate object before him, and does not suffer any imaginary ulterior good to dazzle his eyes and obscure the plain facts which are lying at his feet.

Knowledge obtained by Experiments.—The great scientific advance of modern times has been owing to the method of experiment. The acute intellects of the ancients failed to gain much knowledge of the earth and its inhabitants by mere observation. This is owing to the fact that the materials which make up the organic and inorganic world are so numerous, and the forces which bind them together in complex forms are so subtle, that nothing but analyzing or unravelling these substances can procure for us any insight into their nature. In order to arrive at a knowledge of these complex structures, and their properties, we must arrange new conditions under which they can be observed; in fact, we must perform experiments upon them. The chemist unlocks the secrets of the earth by a continued series of experiments; and by placing substances under the most varied conditions of heat and other powerful agents, becomes acquainted with their ingredients and their characters. Nature herself sometimes performs experiments, or allows us to observe her under altered conditions, and the value of these occurrences is immense. Should the sun for example be covered by the shadow of the moon, astronomers traverse the globe to witness the natural experiment during that minute of time. People in all ages had been gazing with wonder and admiration at the bow in the clouds, but a knowledge of the spectrum only came by experiment, when Newton analyzed the light which passed through a chink in the wall. If great variations of heat and cold occur, we may judge of their importance by the effects on animals and plants, or if the latter be subjected to accident we observe the results which follow the new conditions, and so take advantage of the experiments which Nature performs for us. If we took the hint and wished, for example, to know the effect of heat upon hatching the egg, we should apply heat to one side of it only and then observe the deformity of the chick which would result.

The investigation of Nature is one long experiment. Darwin's work was nothing but a series of experiments on plants and animals. His last work on worms is devoted to a laborious set of experiments, devised in order to ascertain their habits and functions, and the results of his labours on the fertilization of plants were only derived from numerous experiments on the pollen of flowers. If we take up the interesting volume lately written by Sir John Lubbock on ants, bees, and wasps, we shall find the whole book composed of a series of experiments devised to test the habits and characters of these insects. Various devices were thought of to discover their powers of sight, smell and hearing, and also their varied forms of intelligence. All these experiments were no doubt carried out without giving pain to the creatures. But supposing the question were as to the kind of food necessary for their subsistence, the only way to find a solution would be by administering different kinds of aliment, and seeing if these creatures would thrive or starve. Such experiments have been performed and with very remarkable results, there being no law against their trial. It is obvious, however, that much suffering might be inflicted on an animal by starving it to death on a diet inappropriate for it. The question of cruelty, however, would in no way vitiate the experiment or prove its inutility. In the same way, if a drug were administered, and the result noted, it cannot be denied that this would be the only method by which we could ascertain the effect of the drug on the class of animals to which the individual belonged: or if a certain disease were thought to be contagious, this could be proved or disproved only by inoculating an animal with the blood of a diseased person. Again, if the function of some particular part of the body were to be ascertained, the ligature of a blood-vessel, or some like operation, might be undertaken to prove it. These methods of experiment are exactly on a level with those which are employed on inanimate objects and analogous to other simpler ones on living animals. The question of giving pain is of a totally different kind, and must be discussed separately, but it can in no way vitiate the true method, which is the only one of value we can employ to unlock the secrets of Nature in all departments of the organic and inorganic world. In the address lately given by M. Pasteur on his election into the French Academy, he contrasts the two methods of observation and experiment. He says, the experimenter is the conqueror of Nature; he deals with facts which are not yet revealed, which wait to be produced under the influence of natural laws. Of this marvellous method of experiment we may say, not that it suffices for everything, but that it rarely deceives, and deceives those only who make bad use of it. It eliminates certain facts, it calls forth others, it questions Nature, forces her to reply, and does not stop until the mind is fully satisfied. Observation is concerned with the past, from which it can take nothing, and to which it can add nothing; nor does it deal with rigorous demonstration; whilst the peculiarity of the experimental method is that it admits of no other. Mere observation of things, and the more or less legitimate induction which is formed, reasons from that which has been to that which may be. The true experimental method reaches to proof without reply.

The Practical Value of Experiment.—It has been already said that the experimentalist necessarily deals with the simplest possible facts, but, whatever results he obtains, he knows that these are but examples of some great law, which may some time be of the greatest benefit to mankind. The smallest discovery leads to a further investigation, and so on, until a valuable fact is reached, but in this long chain of progressive knowledge it may be sometimes difficult to connect the several links. For example, it is usually said that all the subsequent discoveries in electricity arose out of the primitive one of observing the attraction of pieces of paper by a stick of rubbed sealing-wax. No one denies the statement, because we are sure that all knowledge has a beginning, but it might be difficult to prove as an historical fact, did any one choose to doubt its authenticity. So, again, Newton experimented with light, and observations have gone on from then to the present time. It is open, however, for any one to deny that our knowledge of the spectroscope has any connection with Newton's experiments with the prism. If we take physiological experiments, we find that one simple fact, clearly demonstrated, opens out a larger field of inquiry, the result being that a hundred different exemplifications of the new law are at last recognized, when, perhaps, the original experiment is forgotten. Under these circumstances it is an easy, though thankless, task, to show that the primary experiment brings with it no practical result, as it is also not difficult to assert, with an apparent show of reason, that all the final conclusions are in no way dependent upon it. I may give one example of this. Some years ago Professor Bernard divided the sympathetic nerve in the neck of a rabbit, and he soon observed that the blood-vessels became enlarged, and that side of the rabbit's head more full of blood. What immediate good resulted to the rabbit, or to man, might be difficult to say, but the fact was proved that the size of the blood-vessels is under the control of a particular nerve. The experiment demonstrated a law, and the law was then made applicable to many cases of disease. For example, a patient has a continuous throbbing headache, the pulse is found to be very tense and bounding; the physician bearing in mind the fact already demonstrated, and also another one proved by an experiment on animals—that there are certain drugs which have a paralyzing influence over nerves, gives a particular drug which is ascertained to have this effect, and almost immediately the pulse loses its hardness or tension, and the headache ceases. There cannot be the slightest doubt that this experiment of Bernard led to a far wider knowledge of the influence of the nerves over the blood-vessels in many diseases; all writings on physiology and pathology have allusions to it, and many important practical conclusions have followed. At the same time it is not difficult to deny that these were connected with the original experiment, because so many years have elapsed since its performance, and the conclusions were not at once apparent.

Objects of Experiments on Animals.—Experiments on animals have hitherto been made for three objects—physiological, pathological, and therapeutical—*i.e.*, to ascertain the uses of particular parts of the body, to investigate the nature of disease by means of inoculation, and to observe the operation of drugs.

The purpose of the present Paper is to show that these objects can be obtained by no other means than by experiment.

It may be asserted beyond question, that a knowledge of the material world as well as of all living things upon it, is of the greatest importance to man; that there are persons who in spite of every obstacle will devote their lives to the pursuit of this knowledge; and, thirdly, that this knowledge is to be obtained almost entirely by the method of experiment.